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(54) **Device for separating radiation beam components which issue from an optical fibre**

(57) A device for separating radiation beam components of different wavelengths, which issue from an optical fibre by means of a reflection grating (13) and wavelength selective mirror (12) which permits beam components whose wavelengths are comparatively similar to be separated from each other and from those wavelengths substantially different therefrom.

A wavelength-selective mirror (12) is arranged between the input optical fibre (10) and the reflection grating (13), which mirror reflects the radiation beams of wavelengths λ_{N+1} which are substantially different from the wavelengths $\lambda_1 \ldots \lambda_N$ of a group of radiation beams of comparatively similar wavelength to an output fibre (20), via lens (15) and dichroic filter (14) which serves to suppress any radiation of wavelength $\lambda_1 \ldots \lambda_N$ also reflected by mirror and transmits the radiation beams of comparatively similar (closely spaced) wavelength to the reflection grating 13 which reflects each wavelength at a different angle ($\theta_1 \ldots \theta_N$) and effects spatial separation of the constituent wavelengths which are then focused onto output fibres (1, 2 ... N) via lens (31).

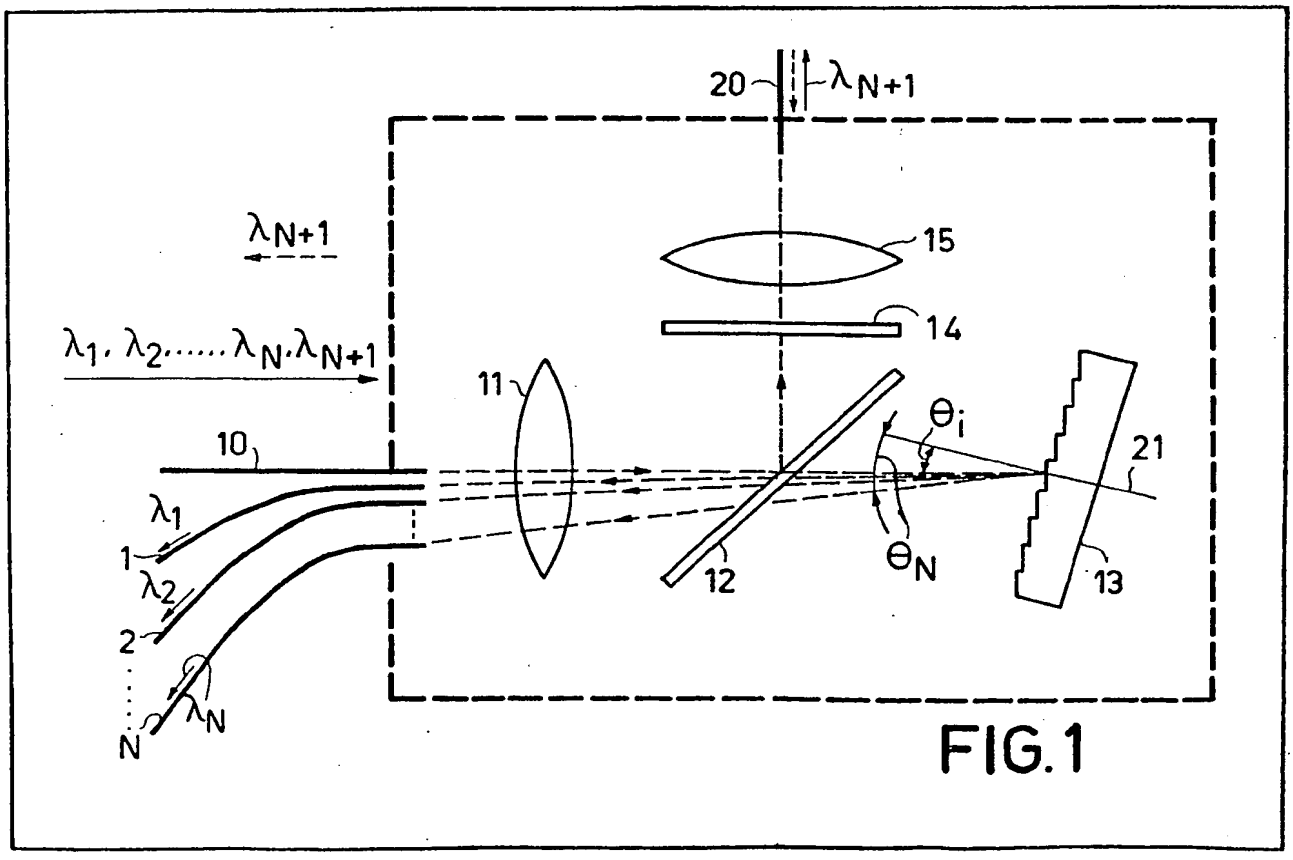

FIG.1

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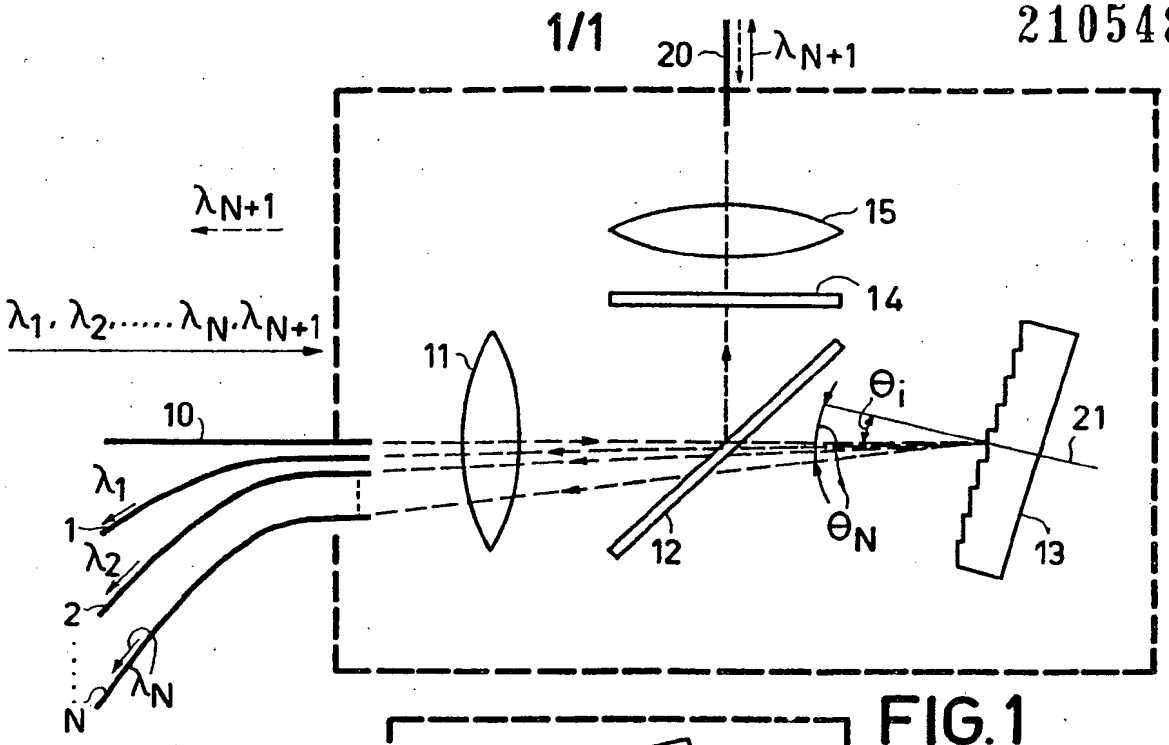

FIG.1

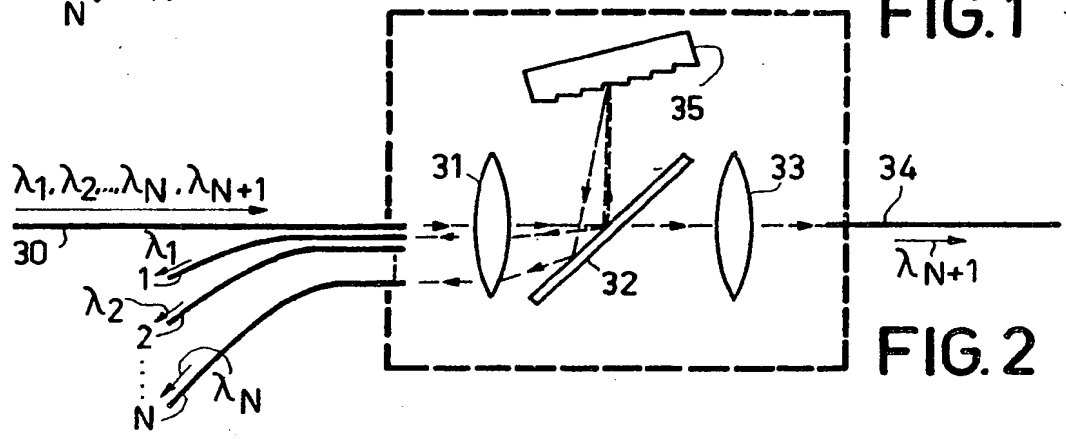

FIG. 2

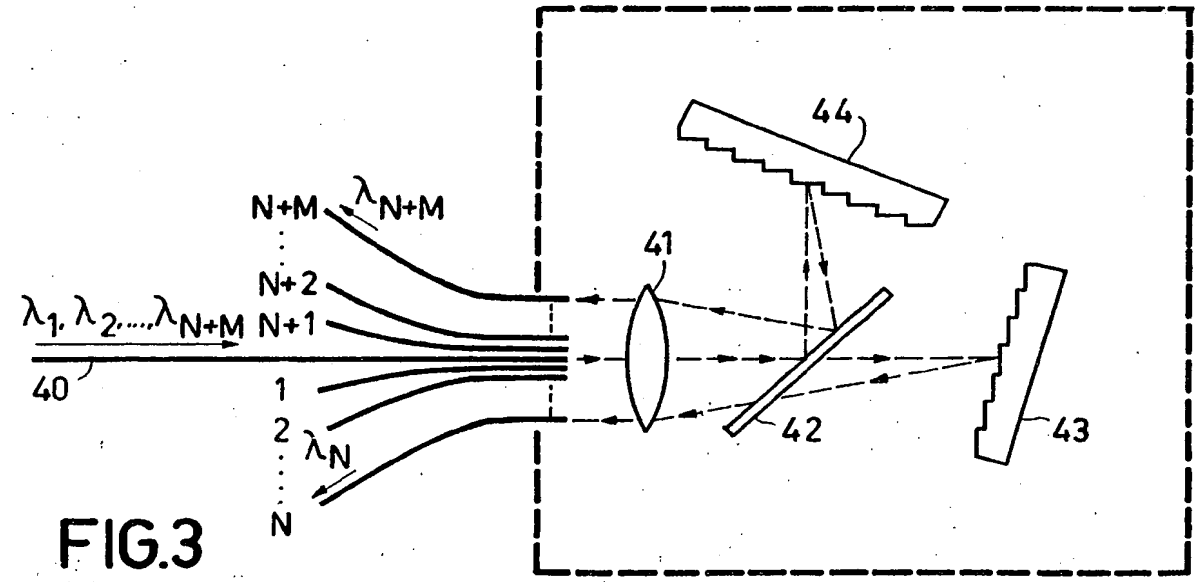

FIG.3

PHN 10151

SPECIFICATION

Device for separating radiation beam components which issue from an optical fibre

The invention relates to a device for separating radiation beam components of different wavelengths which issue from an optical fibre, by means of a reflection grating.

Such a device is known, for example from Applied Optics, Vol. 18, No. 16, page 2835. In the known device the radiation beam components which issue from the optical fibre, are directed at the reflection grating by means of a lens system. The angle at which the radiation components are diffracted in the reflection mode as corresponding beams by the grating will depend on the wavelength of the beam component. After having retraversed the lens system, the individual radiation beams become separated and are routed to a corresponding one of a plurality of output optical fibres. Each of the output fibres corresponds to a beam of wavelength $\lambda_1, \lambda_2, \ldots \lambda_n$ respectively, which is diffracted by the grating at an angle $\alpha_1, \alpha_2, \ldots \alpha_n$ respectively.

The known device has the disadvantage that only radiation beams having wavelengths which are comparatively similar to one another, can be separated by a reflection grating in this way.

The invention aims at providing an improved device of the type mentioned in the opening paragraph, which is also suitable for use with one or more radiation beam components whose wavelengths differ substantially from those of the other radiation beam components of comparatively similar wavelength.

According to the invention there is provided a device for separating radiation beam components of different wavelengths which issue from an optical fibre, by means of a reflection grating, characterised in that a wavelength-selective mirror is arranged between the optical fibre and the reflection grating, which mirror reflects at least one radiation beam component whose wavelength differs substantially from the wavelengths of a group of radiation beam components of comparatively similar wavelength onto a corresponding output optical fibre, and transmits the group of radiation beam components of comparatively similar wavelength to the reflection grating.

Further in accordance with the invention there is provided a device for separating radiation beam components of different wavelengths which issue from an optical fibre, by means of a reflection grating, characterised in that a wavelength-selective mirror is arranged between the optical fibre and the reflection grating, which mirror reflects a group of beam components of comparatively similar wavelength onto the reflection grating, and transmits at least one beam component whose wavelength differs substantially from those of the beam components of comparatively similar wavelengths.

According to an embodiment of the invention, a respective reflection grating is arranged in the path of radiation reflected by the separating mirror and in the path of radiation transmitted by the separating mirror.

Embodiments of the invention will now be described by way of example, with reference to the accompanying drawing, of which:—

Figure 1 shows a first embodiment of a device in accordance with the invention,

Figure 2 shows a second embodiment, and

Figure 3 shows a third embodiment.

In the embodiment shown in Figure 1, a composite beam including components of wavelength $\lambda_1, \lambda_2, \ldots \lambda_N, \lambda_{N+1}$, issues from an input optical fibre 10. The wavelengths $\lambda_1, \lambda_2, \ldots \lambda_N$ are comparatively similar to one another but the wavelength λ_{N+1} differs substantially from the other wavelengths. *Via* a lens 11, the composite beam is made parallel and directed onto a wavelength-selective mirror 12 which transmits the beam components of wavelengths $\lambda_1, \lambda_2, \ldots \lambda_N$ substantially unimpeded, and reflects a beam formed by the beam component of wavelength λ_{N+1}. This last-mentioned beam is transmitted *via* a dichroic filter 14 and a lens 15 to an output fibre 20. The filter 14 suppresses residual radiation of wavelengths $\lambda_1, \lambda_2, \ldots \lambda_N$ reflected by the mirror 12. The beam components of wavelengths $\lambda_1, \lambda_2, \ldots \lambda_N$ are incident on a reflection grating 13 at an angle θ_1 to the normal 21 after being transmitted by the mirror 12. The component of wavelength λ_1 forms a beam which is diffracted in the reflection mode at an angle θ_1 to the normal 21, that of wavelength λ_2 forms a beam at an angle θ_2, and so on. The beams which are thus spatially separated in accordance with their wavelengths are almost entirely transmitted by the mirror 12 and are focussed by the lens 11 at different locations in the focal plane of the lens 11. At these locations output optical fibres 1, 2, ... N are arranged. In this way the respective input beam components of wavelengths $\lambda_1, \lambda_2, \ldots \lambda_N$ are separated from one another.

In one embodiment the fibres 10 and 20 were identical and had a core diameter of 50 μm. The beam components emitted by the fibre 10 had wavelengths of 817 nm, 844 nm and 1325 nm respectively. A beam formed by the component of wavelength 1325 nm entered the fibre 20, that of wavelength λ_1=817 nm the fibre 1, that of wavelength λ_2=844 nm the fibre 2. The fibres 1 and 2 had a core diameter of 100 μm. Since the fibres 10 and 20 were identical, it was possible to reverse the direction of the beam component having a wavelength of 1325 nm without additional losses, i.e. to couple a said beam component issuing from the fibre 20 into the fibre 10.

In the embodiment shown in Figure 2 beam components of wavelengths $\lambda_1, \lambda_2, \ldots \lambda_N, \lambda_{N+1}$ issue from an input optical fibre 30. The wavelengths λ_1 to λ_N of these beam components are comparatively similar to one another and the wavelength λ_{N+1} differs substantially from the other wavelengths. A lens 31 forms the beam components into a parallel beam directed onto a

wavelength-selective mirror 32 which transmits the beam component of wavelength λ_{N+1} substantially completely (for example 90 to 95%) and reflects the beam components of wavelengths λ_1 and λ_N almost completely (for example 99.9%). By means of a lens 33 the transmitted beam is focussed in the focal plane of the lens 33, where an output fibre 34 is arranged. The reflected beam is incident on the reflection grating 35 and the beam components are spatially separated as individual beams after diffraction in the reflection mode from said grating. Subsequently these diffracted beams are reflected by the mirror 32 and are focussed at the input faces of corresponding output optical fibres 1 to N by means of the lens 31. The filter 14 used in the embodiment shown in Figure 1 is now dispensed with. Thus, although the radiation component of wavelength λ_{N+1} of the radiation which has been reflected by the mirror 32 (5 to 10% of the radiation of the wavelength λ_{N+1} incident on the mirror 32) will be reflected by the reflection grating 35, and imaged *via* the mirror 32 and the lens 31, the diffraction angle will be so great that the image will be situated far beyond the entrance planes of the fibres 1 to N. Thus, even without the filter 14, substantially no cross-talk relating to radiation having a wavelength λ_{N+1} will be introduced into the fibres 1 to N.

In the embodiment shown in Figure 3 two reflection gratings are used. Of the radiation beam components of wavelengths λ_1 to λ_{N+M} issuing from an input optical fibre 40, the wavelengths λ_{N+1} to λ_{N+M} are comparatively similar, as a group, but are situated far from the wavelengths λ_1 to λ_N. *Via* a lens 41 the beam components of wavelengths λ_1 to λ_{N+M} are formed into a parallel beam directed onto wavelength-selective mirror 42, which transmits the beam components of wavelengths λ_1 to λ_N almost completely (for example 90 to 95%) and which reflects the beam components of wavelengths λ_{N+1} to λ_{N+M} almost completely (for example approximately 99.9%). The transmitted beam components are diffracted in the reflection mode from a reflection grating 43 to form individual beams which then become spatially separated. After passage through the mirror 42 they are focussed by the lens 41 in the entrance planes of corresponding output optical fibres 1 to N.

The beam components of wavelengths λ_{N+1} to λ_{N+M} reflected by the wavelength-selective mirror 42, are diffracted in the reflection mode from a reflection grating 44 to form individual beams which then become spatially separated. Upon reflection from the mirror 42 they are focussed in the entrance planes of output optical fibres N+1 to N+M by means of the lens 41. It will be apparent that, for the same reasons as those applicable to the embodiment shown in Figure 2, the filter 14 of Figure 1 will also not be required in the embodiment shown in Figure 3.

Claims

1. A device for separating radiation beam components of different wavelengths which issue from an optical fibre, by means of a reflection grating, characterised in that a wavelength-selective mirror is arranged between the optical fibre and the reflection grating, which mirror reflects at least one radiation beam component whose wavelength difffers substantially from the wavelengths of a group of radiation beam components of comparatively similar wavelength, onto a corresponding output optical fibre, and transmits the group of radiation beam components of comparatively similar wavelength to the reflection grating.

2. A device for separating radiation beam components of different wavelengths which issue from an optical fibre, by means of a reflection grating, characterised in that a wavelength-selective mirror is arranged between the optical fibre and the reflection grating, which mirror reflects a group of beam components of comparatively similar wavelength onto the reflection grating, and transmits at least one beam component whose wavelength differs substantially from those of the beam components of comparatively similar wavelengths.

3. A device as claimed in Claim 1 or 2, characterised in that a respective reflection grating is arranged in the path of radiation reflected by the separating mirror and in the path of radiation transmitted by the separating mirror.

4. A device for separating radiation beam components of different wavelengths which issue from an optical fibre, by means of a reflection grating, substantially as herein described with reference to the accompanying drawing.

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